New development of silicon drift detectors and readout electronics for high-resolution and high-count rate X-ray spectroscopy

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Abstract

The purpose of this presentation is to review the current status and possible future trends in the development of Silicon Drift Detectors (SDDs) and related electronics for high-resolution and high-rate X-ray spectroscopy. For several applications, in particular in microanalysis and in experiments at synchrotron light sources, SDDs have become the detector of choice, also with different commercial options available. However, the performances of the available SDD-based detection systems is further challenged by the need to further increase the counting rate capabilities, still keeping good energy resolution. This is particularly true for the ongoing upgrades of actual synchrotron light machines or for the use in future sources where a factor between 10 and 100 to beam-on-sample fluxes may be increased with respect to present conditions. More commonly used SDDs-based systems are usually limited to single- or few-channel systems (4-6 units). This motivates further developments of this technology toward multi-channels systems (e.g. 16-24 or even larger number of units) possibly based on a modular approach to build versatile systems for synchrotron applications, with also the advantage of an easier and cheaper replacement of malfunctioning units. New developments based on this approach will be presented in the talk. Regarding the front-end electronics, which covers a fundamental role in the noise performances, therefore on achievable energy resolution, the recent availability of CMOS preamplifiers to be directly connected to the detector as replacement of conventional JFETs allows an improvement of performances, in particular in the direction of high-count rate spectroscopy (e.g. 1Mcounts/s/channel). As an example, and energy resolution FWHM at 5.9keV of 126eV and 140eV has been measured with CUBE preamplifier at an analog shaping time of 250ns and digital peaking time of 100ns, respectively. The capability to obtain a satisfactory resolution at very short processing time provides the additional benefit to potentially relax the cooling conditions for the detector, as the contribution to the resolution due to the leakage current is less and less significant at short processing times. This opens the possibility to operate SDDs with a resolution better than 150eV even close to room temperature, with potential simplification of the detector apparatus.

For what concerns processing electronics, the push towards high-rate spectroscopy measurements further justifies the use of digital pulse processors in the detection system and commercial solutions are available (e.g. XSPRESS and Falcon systems). However, the perspective to build detection systems with few tens, maybe few hundreds, of readout channels, make the use of analog readout ASICs still of interest.